Humanities and Social Sciences Letters
2023 Vol. 11, No. 1, pp. 83-99
ISSN(e): 2312-4318
ISSN(p): 2312-5659
DOI: 10.18488/73.v11i1.3302

Students' innovativeness and higher education for sustainable development: A bibliometric approach

Xiang Li[1+]
Ruihui Pu[2]

[1]*School of Foreign Languages and Cultures, Panzhihua University, Panzhihua, Sichuan, 617000 China.*
Email: willmer@163.com
[2]*Faculty of Economics, Srinakharinwirot University, Bangkok, 10110 Thailand.*
Email: ruihui@g.swu.ac.th


(+ Corresponding author)

Article History
Received: 8 April 2022
Revised: 29 September 2022
Accepted: 20 January 2023
Published: 23 February 2023

Keywords
Bibliometrics
College students
Higher education
Innovation
Sustainable development
VOS viewer.

ABSTRACT

Innovativeness plays a decisive role in the progress of society, the sustainable development of nations, and the success of individuals in the era of information technology and knowledge economy, especially because the world is now confronted with major challenges such as climate change, environmental degradation, social inequality and resource exhaustion that have no ready solutions. As cradles for talent, higher education institutions attach great importance to promoting the innovative capabilities of their students. This study aims to introduce the existing studies on students' innovativeness in institutions of higher learning for sustainable development. This study applies a bibliometric analysis by conducting collaboration, co-citation, co-reference, and co-occurrence analysis on university students' innovativeness toward sustainable development. A total of 1,531 academic publications have been collected from the Web of Science Core Collection database from 2011 to 2021 and further analyzed. The major researchers and publications, productive countries or regions, collaborative institutions, research hotspots, and trends related to the innovativeness of college students are identified in this study. By adopting Co-occurrence (COOC) and VOSviewer to analyze and visualize the data, this research reveals that college students' innovation capability continues to be an emerging research issue. Training, entrepreneurship education, and entrepreneurial intention are identified as the gaps for further studies. The results of this study suggest that academia in higher education institutions and government agencies are strongly encouraged to enhance the innovativeness of college students to tackle the unsustainable issues haunting society today.

Contribution/Originality: The paper contributes to the revelations of the main researchers, major journals, high-yield countries or regions, cooperating institutions, knowledge landscape, and research hotspots of college students' innovativeness based on the academic literature between 2010 and 2021. It sheds light on the research status in the past decade and identifies the research trends connected with undergraduates' innovativeness in higher education.

1. INTRODUCTION

Innovativeness in higher education institutions plays an increasingly crucial role in determining the economic prosperity of all countries across the world (Phelps, 2014; Wang, Ren, Wang, & Yu, 2018). Human society has stepped into the era of information and knowledge that is more dependent on innovation. The fierce competition among countries is a competition of talents and innovation. As early as 1972, the United Nations Educational, Scientific and Cultural Organization (UNESCO) put forward the cultivation of creativity as one of the most critical contemporary educational goals in its report *Learning to Be: The World of Education Today and Tomorrow*. As the key outcomes of

higher education (McWilliam, 2009), the innovativeness of college students is the emerging vitality of social development and plays a significant part in the improvement of productivity, the advancement of science and technology, and the promotion of employment (Li, 2017). At the same time, the development of technologies such as the internet (Gulati, Reid, & Gill, 2020), big data (Hou, 2019), artificial intelligence (Cantú-Ortiz, Galeano Sánchez, Garrido, Terashima-Marin, & Brena, 2020; Wu, Shen, & Lv, 2021), and visual technology (Borgen, Ropp, & Weldon, 2021; Kumar, Pandey, & Rahman, 2021; Obeid & Demirkan, 2020) has also provided unprecedented opportunities for nurturing college students' innovative capabilities. As a result, the cultivation of such capabilities has become a top priority for all higher education institutions in different countries across the world (Touahmia et al., 2017), and the research on college students' creativity has also received extensive attention from the academic community.

Innovation is regarded as a multidimensional and complex construct (Guilford, 1956; Kupers, Lehmann-Wermser, McPherson, & Van Geert, 2019) with three mutually reinforcing dimensions: the intrapersonal, the social, and the cognitive (Selznick & Mayhew, 2018). Plucker, Beghetto, and Dow (2004) define innovation as the interaction between ability, process, and environment through which individuals or groups produce original, meaningful and perceivable products in the social environment. Innovation ability refers to the overall capabilities of fulfilling the procedure of innovation and attaining innovative results through knowledge (Hao, 2021) with invention and discovery as its embodiment (Hu, Ding, & Ni, 2016), which mainly includes innovative character, awareness, thinking, and experience (Wen, Liu, Beaulieu, Wang, & Wang, 2016). Several researchers have explored different approaches to measuring creativity, which include the tests for divergent thinking, such as the Consensual Assessment Technique (Amabile, 1982), the Torrance Tests of Creative Thinking (Kim, 2017), and questionnaires such as the Runco Ideational Behavior Scale (Runco, Plucker, & Lim, 2001), the Creative Achievement Questionnaire (Carson, Peterson, & Higgins, 2005), and the Kaufman Domains of Creativity Scale (Kaufman, 2012). Research has also been done on the factors that shape or influence the creativity of college students. Parental warmth and parental rejection (Guo, Zhang, & Pang, 2021) and public service motivation (Jung, Lee, & Workman, 2018) are positively associated with creativity. Gregariousness, excellence, humility, kindness and other positive psychological traits affect the sense of innovation among students at institutions of higher learning (Zhang, Liu, Wang, & Yang, 2020). Students' creativity is supported by learner involvement, external environment, and academic atmosphere (Richardson & Mishra, 2018).

Related research on the innovation capability of college students has been conducted in a variety of research domains, such as education (Shoop & Ressler, 2011; Taylor, Esmaili Zaghi, Kaufman, Reis, & Renzulli, 2020), psychology (Carter, Hass, Charfadi, & Dinzeo, 2019), engineering (Genco, Hölttä-Otto, & Seepersad, 2012), nursing and health care (Dai, Wei, Chen, & Ju, 2019), business and management (Gugerty & Teeven, 2015), and information science (Mizrachi & Bates, 2013). However, a bibliometric and visual analysis of the literature concerning this research topic from 2011 to 2021 has not been done yet, especially in light of sustainable development that is of paramount importance to the current and future generations because the world is now subject to climate change (Holden, 2019), resource exhaustion (Ahamad & Ariffin, 2018), and wildlife decline (Brito et al., 2018). Innovation is at the core of pushing society onto the track of a more sustainable path (Sandri, 2013), but the innovative potential of college students for sustainable development has long been neglected (Braßler & Schultze, 2021). Blewitt and Senior (2010) argued that future graduates will be required to fully understand sustainability as an indispensable part of their knowledge and skills and is a necessary supplement to their professions and disciplines. Based on the analysis of collaboration, co-citation, co-reference and co-occurrence of the retrieved bibliographic data, this paper reveals the main researchers, major journals, high-yield countries or regions, cooperating institutions, knowledge landscape and research hotspots to shed light on the research status in the past decade and identifies the research trends connected with college students' innovativeness in higher education.

2. DATA AND METHODS

2.1. Data Source

The current research obtained bibliographic data from the Web of Science (WoS) Core Collection on March 29, 2021. The WoS is considered to be the most reliable and influential resource among the leading bibliographic databases for academic publications (Birkle, Pendlebury, Schnell, & Adams, 2020). The keywords of research topics are 'innovation' and 'college students' or 'innovation' and 'undergraduate' or 'creativity' and 'undergraduate' or 'creativity' and 'college students'. English was the language selected, the document type was 'article', and the timespan was set between 2011 and 2021. Editions were restricted to Science Citation Index Expanded (SCI-Expanded) and the Social Science Citation Index (SSCI). As a result, 1,531 articles were obtained via this search strategy.

2.2. Research Method

Bibliometric analysis that reveals the network of co-authors, co-citations, co-references, and co-occurrences can demonstrate the intellectual framework of a research area (Chen, Dubin, & Kim, 2014). This research utilizes two bibliometric analysis tools – Co-Occurrence 6.7 (COOC 6.7) and VOSviewer 1.6.13. COOC 6.7 is mainly used for data analysis, data mining, and data visualization in the field of bibliometrics and has excellent performance in terms of accuracy, function, and operation. It can process multiple databases at the same time, such as Web of Science, PubMed, EI, Scopus, and ScienceDirect, and implement synonym merging; frequency counting; the co-occurrence, dissimilarity, bimodal, coupling matrices; pedigree, clustering and time zone graphs; and theme evolution paths (Xueshudiandi, 2020). VOSviewer 1.6.13 is free JAVA-based bibliometric software developed by Van Eck and Waltman from the Centre for Science and Technology Studies at Leiden University in the Netherlands. VOSviewer is a well-known scientific tool for knowledge plots based on citation, co-citation, co-authorship, and bibliographic coupling of bibliographic references (Van Eck & Waltman, 2010) and has been adopted in bibliometric analysis in various knowledge fields (Williams, 2020). In this study, COOC 6.7 is used to count frequency and draw a weighted time-zone map of keywords. VOSviewer 1.6.13 is adopted to analyze and visualize publication information, authors, journals, institutions, countries or regions, and keywords.

3. RESULTS

3.1. Publication Reviews

As shown in Figure 1, research on the innovativeness of college students increased continuously from 2011 to 2020.

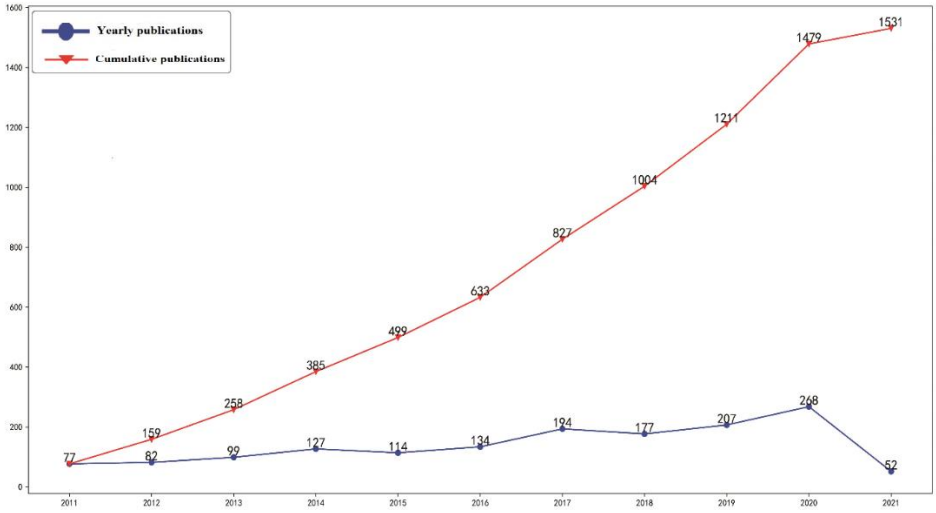

Figure 1. Distribution map of the annual publications from the Web of Science.

It needs to be clarified that the 52 journal articles were published only in the first three months of 2021. The number of published academic papers reached 268 in 2020, nearly quadrupling the number of publications of 2011. At the same time, the total publications rose to 1,479 at the end of 2020, 19 times more than in 2010, which proves that the innovativeness of college students is a research hotspot with a growing trend.

3.2. Most Cited Articles

In the current academic community, the influence and significance of a paper are assessed mainly by the number of times it has been cited by other researchers in the bibliographic database. According to the Web of Science Core Collection, the 1,531 articles retrieved in this research have been cited 13,633 times in total. The top 10 most frequently cited articles, which have been cited more than 110 times, are listed in Table 1.

Table 1. Top 10 references in the field of innovativeness of college students from 2011 to 2021.

Ranking	Year	Citations	Journal	Author(s)
1	2011	314	Psychological Science in the Public Interest	Subotnik et al. (2011)
2	2016	215	Computers in Human Behavior	Sheldon and Bryant (2016)
3	2014	175	Computers & Education	Arteaga Sánchez et al. (2014)
4	2011	175	CBE: Life Sciences Education	Andrews et al. (2011)
5	2011	154	Journal of Mechanical Design	Linsey et al. (2011)
6	2011	149	Journal of Knowledge Management	Xue et al. (2011)
7	2012	141	Research Policy	Astebro et al. (2012)
8	2012	131	Journal of Personality	Markowitz et al. (2012)
9	2011	128	Psychology of Violence	Banyard and Moynihan (2011)
10	2016	114	Information & Management	Shiau and Chau (2016)

The most cited article was composed by Subotnik, Olszewski-Kubilius, and Worrell (2011), which introduced a comprehensive definition of giftedness and offered some suggestions for the future development of gifted education that includes general and professional abilities, creativity, motivation, mindset, commitment, passion, interest, and opportunity (Subotnik et al., 2011).

The second most influential article, which was cited 215 times, found that a positive relationship exists between the college students who scored highly in interpersonal communication and used Instagram for coolness, creativity, and surveillance (Sheldon & Bryant, 2016).

The articles by Arteaga Sánchez, Cortijo, and Javed (2014) and Andrews et al. (2011) rank third with 175 citations each. The former identified the factors that stimulated students in higher learning to use Facebook for academic purposes based on the models used for the diffusion and adoption of technology innovation (Arteaga Sánchez et al., 2014). The latter showed no correlation between learning outcomes and the adoption of active learning instruction among students (Andrews, Leonard, Colgrove, & Kalinowski, 2011).

Linsey et al. (2011) suggested that the combination of Brainsketching, C-Sketch, and Gallery could produce more ideas and increase their quality, thereby promoting creativity and innovation in engineering design. They also showed that the interactions between individuals and groups had a prominent place in the process of generating new ideas.

Based on a survey of 434 students in a large university in the United States, Xue, Bradley, and Liang (2011) found that an innovation team whose members trusted each other and were led by authorized leaders would have a more positive attitude toward sharing knowledge and tended to generate knowledge-sharing behavior.

Astebro, Bazzazian, and Braguinsky (2012) conducted case studies on Massachusetts Institute of Technology, Halmstad University, and Chalmers University of Technology, which have innovation-related programs, and found that recent college graduates were twice as likely as the faculty to establish start-ups three years after their graduation. It is a common phenomenon for graduates to start businesses regardless of the type of school.

Markowitz, Goldberg, Ashton, and Lee (2012) found that a high level of aesthetics, creativity, and curiosity, rather than the personality traits connected with altruism, may stimulate the performance of environmentally friendly behavior.

The paper by Banyard and Moynihan (2011) explored the correlation of practical helping behaviors and the prevention of sexual and intimate partner violence among students in higher learning institutions, though they mentioned that innovations in preventing violence encouraged people to become positive bystanders.

Shiau and Chau (2016) found that the motivational model, technology acceptance model, innovation diffusion theory, theory of planned behavior, self-efficacy, and service quality can all firmly explain the willingness to use cloud computing in the classroom, which is an innovative form of information technology characterized by demonstrability, visibility, and testability to enhance students' learning. Except for computer self-efficacy and trialability, all the other factors of the abovementioned models had a significant positive impact on the willingness to use cloud computing in the classroom. The proposed united model showed that perceived usefulness had the most decisive and positive impact on students' intentions, and the other influencing factors included attitude, cloud service quality, perceived behavior control, results display, visibility, and cloud self-efficacy.

3.3. Journals

Table 2 lists the top 23 journals that published academic articles related to the creativity or innovativeness of college students, which could help future researchers find the relevant journals to submit their relevant papers. The *International Journal of Engineering Education* and the *Creativity Research Journal* are the most prolific in this research field, with more than 40 publications in the studied period, followed by *Agro Food Industry Hi-Tech*; *Frontiers in Psychology*; *Thinking Skills and Creativity*; *Psychology of Aesthetics, Creativity, and the Arts*; *Journal of Chemical Education*; *Sustainability*; *Journal of Creative Behavior*; *Journal of Nursing Education*; and *BMC Medical Education*, with more than 20 published literature. These journals mainly concentrate on the research field in education, psychology, engineering, health care sciences and service.

Table 2. Top 23 journals for innovativeness of college students from 2011 to 2021.

Ranking	Journal	Publications	Ranking	Journal	Publications
1	International Journal of Engineering Education	65	13	Medical Teacher	18
2	Creativity Research Journal	48	14	Academic Medicine	17
3	Agro Food Industry Hi-Tech	36	15	Personality and Individual Differences	16
4	Frontiers in Psychology	33	16	Nurse Education Today	15
5	Thinking Skills and Creativity	32	17	Journal of Engineering Education	15
6	Psychology of Aesthetics, Creativity, and the Arts	30	18	International Journal of Technology and Design Education	15
7	Journal of chemical education	29	19	PLoS ONE	13
8	Sustainability	29	20	Computers in Human Behavior	13
9	Journal of Creative Behavior	26	21	International Journal of Art & Design Education	12
10	Journal of Nursing Education	23	22	Eurasia Journal of Mathematics Science and Technology Education	11
11	BMC Medical Education	21	23	International Journal of STEM Education	10
12	Educational Sciences: Theory & Practice	19			

The *International Journal of Engineering Education* (Impact Factor: 0.97, Hirsch Index: 50) is a peer-reviewed journal that publishes academic manuscripts that only address issues in engineering education. The *Creativity Research Journal* (Impact Factor: 2.37, Hirsch Index: 82) publishes academic research on all fields of creativity covering behavioral, educational, clinical, cross-cultural, cognitive, organizational, psychometric, and social aspects, etc., through a double-blind and anonymous review process.

A co-citation analysis of the journals is helpful in tracking the distribution of academic resources and the cooperation between the journals. The number of citations of a journal determines the size of its nod in the co-citation map (see Figure 2), and the frequency of the co-citation of journals in the literature is represented by the distance between the respective nodes (Chen & Liu, 2020). Figure 2 (minimum number of citations of a source ≥ 20) shows that the *Creativity Research Journal*, the *Journal of Personality and Social Psychology*, and the *Journal of Creative Behavior* are the most co-cited journals, which also have the strongest association power within each co-citation group. It is noteworthy that two of them are also among the top 23 most productive journals.

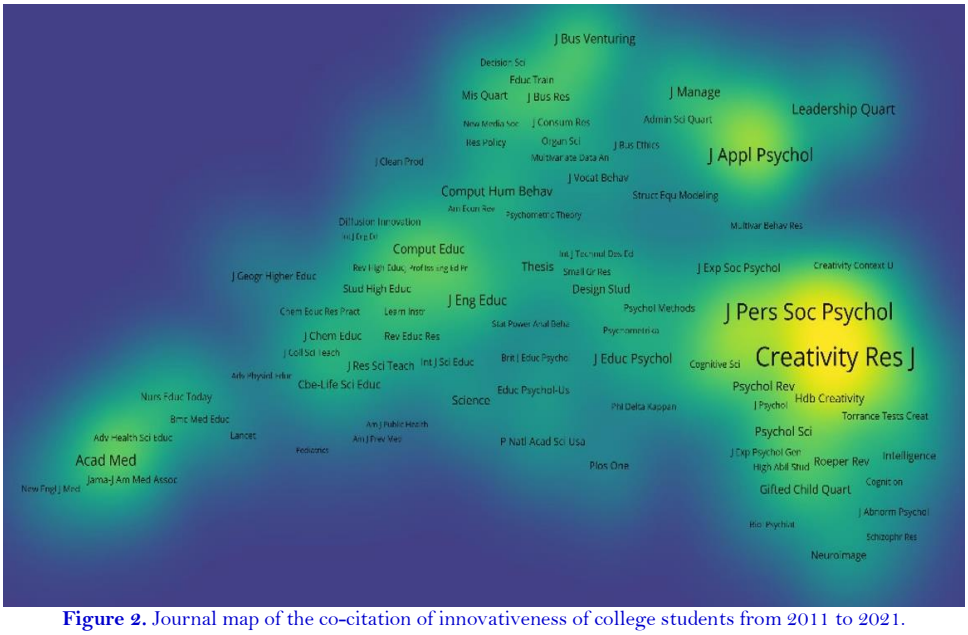

Figure 2. Journal map of the co-citation of innovativeness of college students from 2011 to 2021.

3.4. Authorship

A total of 4,895 authors contributed to the 1,531 retrieved papers. Table 3 lists the leading contributors who published more than five academic papers in the field of the innovation capability of college students. The most prolific author is (Gibson & Mumford, 2013) with 14 articles over the past decade, which were all co-authored with other scholars. Figure 3 shows that the collaborative networks between the authors can be clustered into three groups (minimum number of documents of an author ≥ 2). Group #1 includes Gibson and Mumford (2013), Partlow, Medeiros, and Mumford (2015) and Vessey, Barrett, and Mumford (2011), whose principal research interests are cognition, leadership, forecasting, idea evaluation, creative problem solving, vision, and constraints. Group #2 includes Barrett et al. (2013), Day (2012), Hester et al. (2012) and Peterson et al. (2013) and Peterson et al. (2018), who focus on exploration, problem-based learning, innovative teaching, self-regulation, active learning strategies, learning environment, and creativity barriers. Group #3 includes McIntosh, Mulhearn, and Mumford (2021), Medeiros, Steele, Watts, and Mumford (2018), Steele, Hardy, Day, Watts, and Mumford (2021) and Watts et al. (2020), whose main research focuses are idea evaluation, creative problem solving, cognition, lifelong learning, leadership, stories, and idea sources.

Table 3. Top 17 most prolific researchers related to the innovativeness of college students from 2011 to 2021.

Ranking	Author Name	Number of Publications	Ranking	Author Name	Number of Publications
1	Mumford, M. D.	14	10	Medeiros, K. E.	6
2	Kaufman, J. C.	13	11	Zhang, Q. L.	6
3	Zhang, S.	10	12	Selznick, B. S.	5
4	Zhang, J. H.	9	13	Yeh, Y. C.	5
5	Watts, L. L.	7	14	Hass, R. W.	5
6	Kharkhurin, A. V.	6	15	Wang, Y.	5
7	Mayhew, M. J.	6	16	Valcke, M.	5
8	Chen, H. C.	6	17	Daly, S. R.	5
9	Qiu, J.	6			

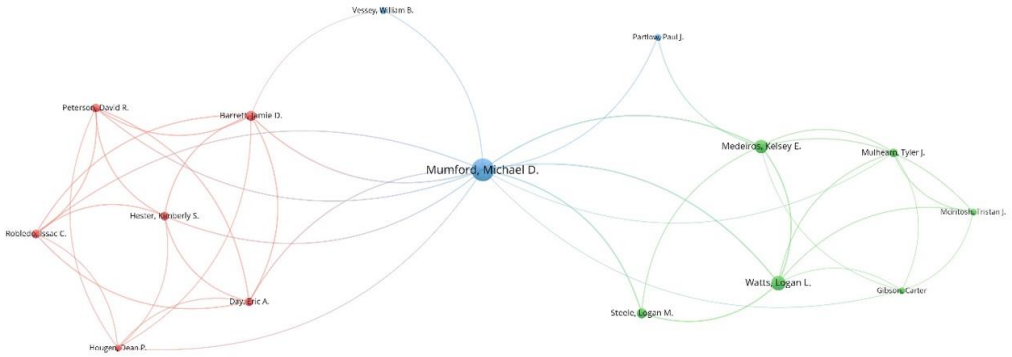

Figure 3. Co-authorship map.

3.5. Countries/Regions

The 1,531 bibliographic references obtained in this study were drafted by 81 countries or regions. The top 20 most prolific countries or regions that published over 15 pieces of literature from 2010 to 2021 are listed in Table 4. The United States of America contributed 686 academic papers, which nearly triples the publications by China in second place, and it is almost eight times more than that of England, which is in third place. Figure 4 shows the collaboration between these countries or territories that are grouped into six clusters by VOSviewer (minimum number of documents of a country ≥ 5, minimum number of citations of a country ≥ 1, minimum cluster size ≥ 5). The biggest nod in each cluster signifies the contributor with the greatest link strength in the corresponding collaborative network. Cluster #1: Spain, Chile, France, Japan, Mexico, Ecuador, Portugal, Brazil, and Colombia; Cluster #2: USA, Canada, Germany, Singapore, Finland, Northern Ireland, Israel, and Hungary; Cluster #3: Malaysia, Netherlands, Ireland, Italy, Belgium, Wales, and Norway; Cluster #4: Saudi Arabia, Turkey, Russia, Austria, India, Pakistan, and the United Arab Emirates; Cluster #5: The People's Republic of China, Taiwan, South Korea, Scotland, and the Philippines; Cluster #6: England, Australia, New Zealand, Sweden, and Iran.

Table 4. Top 20 most prolific countries/regions of publications.

Ranking	Country/Region	Number of Publications	Ranking	Country/Region	Number of Publications
1	USA	686	11	Brazil	24
2	People's Republic of China	242	12	Italy	20
3	England	87	13	Malaysia	20
4	Australia	86	14	Ireland	19
5	Taiwan	73	15	Singapore	18
6	Canada	72	16	New Zealand	18
7	Spain	58	17	Netherlands	18
8	South Korea	37	18	Mexico	17
9	Germany	28	19	Turkey	17
10	India	26	20	Scotland	15

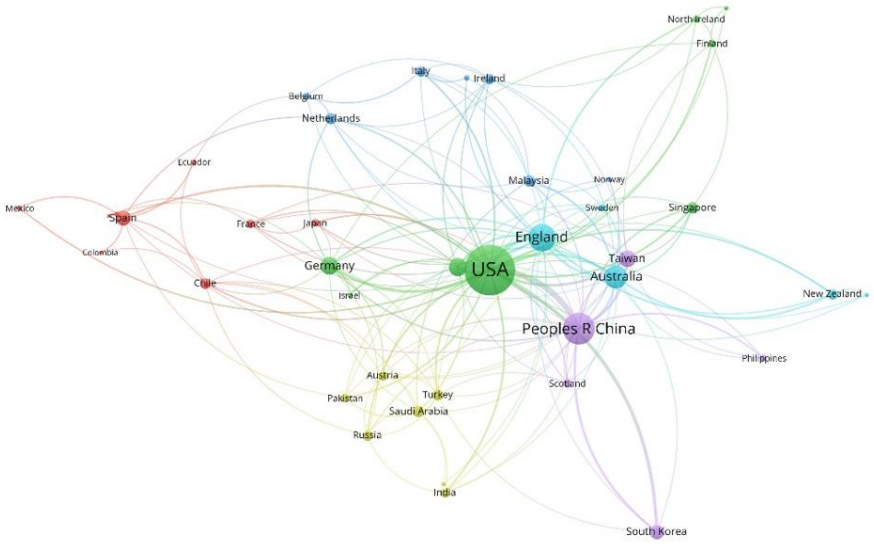

Figure 4. Association between countries/regions.

3.6. Organizations

The most productive institutions with over ten publications from 2011 to 2021 are listed in Table 5. It is worth noting that all of the top ten universities are from the USA. To be more specific, on the list of the top 31 most prolific institutions, 25 are from the USA, three are from China's mainland, one is from Taiwan, one is from Australia, and one is from Canada. Figure 5 illustrates the cooperative networks between the major institutions that can be divided into five main clusters (minimum number of documents of an organization ≥ 10, minimum cluster size ≥ 3). Cluster #1 includes Purdue University, Arizona State University, University of Colorado, Stanford University, University of Pittsburgh, University of California (Berkeley), University of Minnesota, University California (San Francisco), and Vanderbilt University, and focus on engineering education, entrepreneurship, medical education, midwifery, openness to experiences, personality, and design education.

Table 5. Top 31 most prolific organizations.

Ranking	Name of Organization	Publications	Ranking	Name of Organization	Publications
1	Purdue University	21	17	University of Toronto	12
2	University of North Carolina	19	18	University of Texas, Austin	12
3	University of Michigan	18	19	Yale University	11
4	University of Oklahoma	17	20	Ohio State University	11
5	University of Pittsburgh	17	21	Iowa State University	11
6	University of Connecticut	16	22	Washington University	11
7	Arizona State University	15	23	Texas A&M University	11
8	Vanderbilt University	15	24	University of South Florida	11
9	University of California, San Francisco	14	25	Central China Normal University	11
10	Stanford University	14	26	Monash University	11
11	James Madison University	14	27	Pennsylvania State University	11
12	University of Minnesota	14	28	Shandong Normal University	10
13	University of California, Berkeley	14	29	The City University of New York	10
14	University of Colorado	14	30	University of Nebraska	10
15	National Taiwan Normal University	13	31	Southwest University	10
16	University of Illinois	13			

Cluster #2 includes University of Texas at Austin, University of Illinois, National Taiwan Normal University, University of Toronto, and Texas A&M University, and focus on technology, medical education, curriculum, emotion,

teaching/learning strategies, intervention, and engineering education. Cluster #3 includes Ohio State University, Pennsylvania State University, Iowa State University, University of Michigan, and James Madison University, which concentrate on design education, medical education, clerkship, personality, concept generation, assessment, idea generation, and ethical reasoning. Cluster #4 includes University of North Carolina, Southwest University, University of Connecticut, and Yale University, which prioritize divergent thinking, personality, education, intelligence, teaching methods, medical education, self-efficacy, evaluation, and originality. Cluster #5 includes University of South Florida, The City University of New York, University of Oklahoma, and Washington University, whose research focuses are on cognition, idea evaluation, leadership, creative problem solving, entrepreneurship, forecasting, vision, ethics, sustainability, and collaborative/cooperative learning.

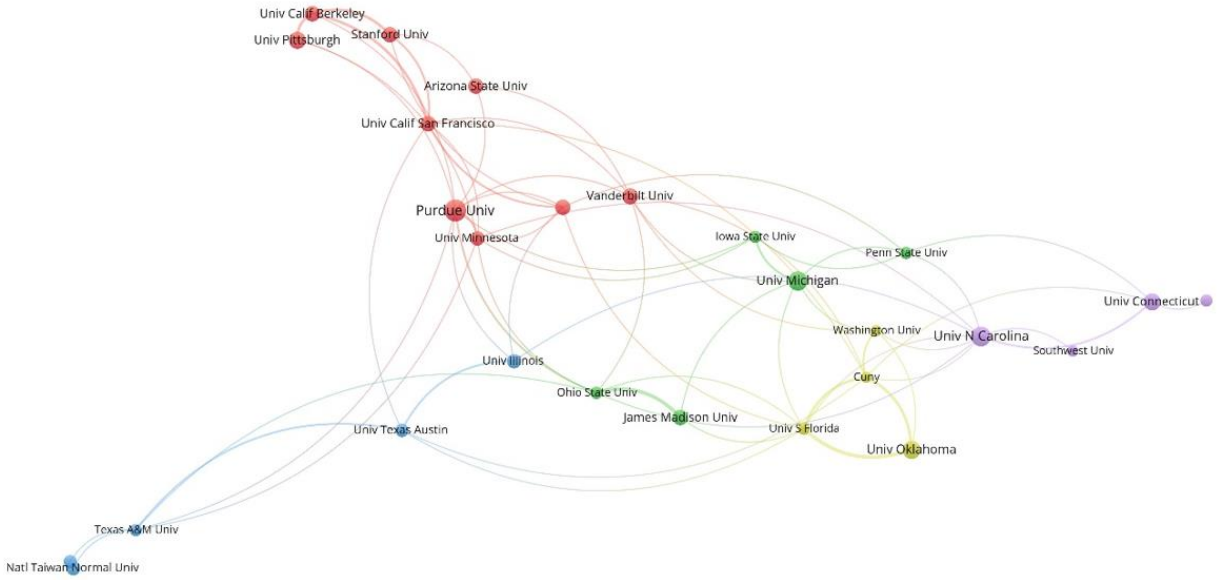

Figure 5. Cluster map of organizations.

4. DISCUSSION

4.1. Hot Research Topics

Table 6 lists the top 15 keywords appearing more than 20 times in the retrieved literature over the past decade. Besides "creativity" and "innovation", which are the topic words of this research, the other most frequent keywords are education, higher education, engineering education, entrepreneurship, medical education, curriculum, college students, divergent thinking, design education, active learning, and assessment. These high-frequency keywords show that the research hotspots related to college students' innovative ability are mainly reflected in the fields of entrepreneurship, critical thinking, and autonomous learning in engineering, medicine, design, and other higher education disciplines.

Figure 6 shows the co-occurrence of the keywords and divides them into five clusters with an occurrence ≥ 10 and a minimum cluster size ≥ 5. Each cluster indicates a hot research theme within the field of the creativity of college students. Cluster #1 comprises 15 items and mainly focuses on creativity in educational innovation, such as active learning, critical thinking, curriculum development, and assessment, especially in medical education. Medical students should have a strong sense of creativity and obtain the sustainable development of entrepreneurial programs in the innovation and entrepreneurship of medical education (Li, 2017). As the outbreak of the Covid-19 pandemic hit the world at an unprecedented scale, it brought an urgent need to innovate medical education (Pravder et al., 2021; Southworth & Gleason, 2021).

Cluster #2 includes 13 items and studies innovation in design and engineering education from the perspectives of pedagogy, sustainability, and technology. Challenges, such as fast-growing industry needs, engineering practices, and students' own career prospects, demand innovations in engineering education that integrates multidisciplinary

knowledge, leadership, communication, entrepreneurship, sustainability, creation, and lifelong learning (Jamieson & Shaw, 2019; Tekmen-Araci & Mann, 2019). The application of design strategies and tools can promote critical thinking in the initial stages of engineering design, and diversified choices in the design process will bring more creative and innovative results (Lee et al., 2021).

Cluster #3 includes seven items and explores entrepreneurship in higher education from the perspectives of entrepreneurial intent, self-efficacy, and gender. Entrepreneurial self-efficacy is a mediator between self-perceived creativity and entrepreneurial propensity, and the support for creativity from families and colleges and participation in creativity courses can significantly predict self-perceived creativity (Laguía, Moriano, & Gorgievski, 2019). Many countries have formulated national strategies to support college students and youngsters to become cyber-entrepreneurs to grow the economy and boost innovation since cyber-entrepreneurship is a burgeoning practice of innovation in the information age. Self-efficacy of information technology-related entrepreneurship has a significant positive effect on cyber-entrepreneurial propensity, while thinking positively has no such effect. However, thinking positively is a moderating factor between self-efficacy in internet entrepreneurship and the intention to start an e-commerce business (Chang, Shu, Wang, Chen, & Ho, 2020).

Cluster #4 includes five items and expounds creativity from divergent thinking, personality, and motivation. General cognitive ability and creative personality traits are predictors of creativity in terms of divergent thinking, while cognitive and motivational variables as well as course grades can predict creative performance. Motivation has a predictive effect on creative activity and creative ideation (An, Song, & Carr, 2016).

Table 6. Top 15 keywords from the literature.

Ranking	Keywords	Frequency	Ranking	Keywords	Frequency
1	Creativity	200	9	Medical education	25
2	Innovation	92	10	College students	24
3	Education	56	11	Undergraduate	23
4	Higher education	49	12	Divergent thinking	23
5	Engineering education	39	13	Design education	22
6	Entrepreneurship	28	14	Active learning	22
7	Undergraduate medical education	28	15	Assessment	21
8	Curriculum	27			

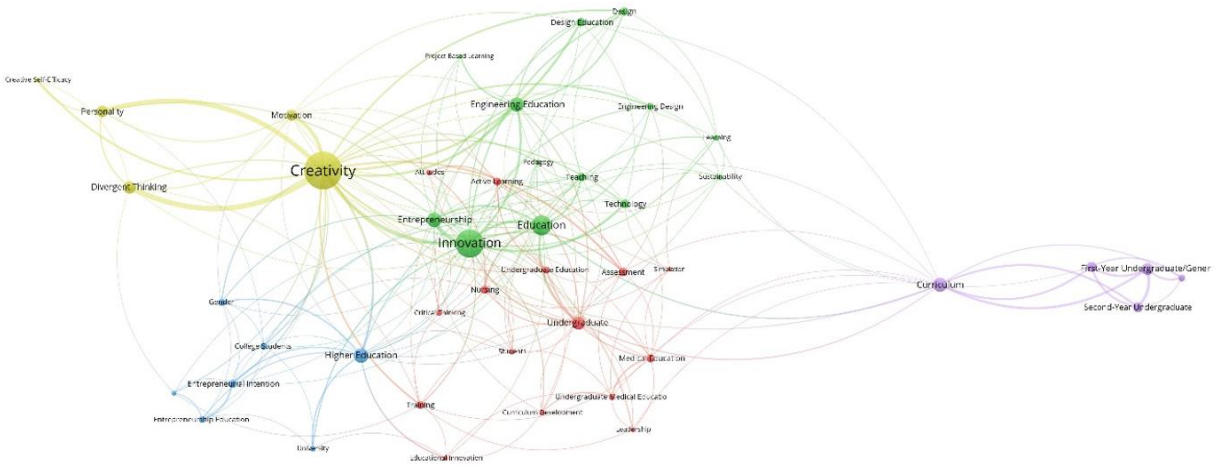

Figure 6. Co-occurrence map of highly frequent keywords.

Cluster #5 also has five items, and its major research focuses are the curriculum of first-year and second-year undergraduates from the aspects of collaborative learning and hands-on learning. The application of sustainability to the university engineering curriculum brings about a noticeable improvement in knowledge and attitudes and modest changes in enabling new behaviors (Qu, Huang, & Zhou, 2020). Educators in the engineering field need to take more

effective measures to make certain that creativity is a clear result of learning in the engineering curriculum because innovation has been proven to be a crucial competency for engineering professionals (Valentine, Belski, Hamilton, & Adams, 2019). Innovations in higher education, such as peer-led team learning (Frey, Fink, Cahill, McDaniel, & Solomon, 2018), the supplemental instruction model (Alden, 2017), and technology-enhanced learning (Urban, 2017), for first-year and second-year college students can improve their learning experience and enhance their academic achievements.

4.2. Research Trend

Figure 7 is a weighted time-zone map that displays the evolution of the research keywords and also reveals the research frontiers and trends. Each node on the map represents a keyword whose frequency determines the size of the node. The time of the keyword on the map is the average weighted year based on the retrieved bibliographic data. The specific formula is as follows:

$$\text{wy} = \frac{\sum_i year_i * counts_i}{\sum_i counts_i}$$

In this formula, wy is weighted year, $year_i$ refers to the year in which the keyword appears, and $counts_i$ refers to the frequency of the year in which the keyword appears.

The weighted time-zone map of keywords can reflect the changing trend of research topics in the field over time. As shown in Figure 7, the latest research trends in the area of college students' innovativeness can be categorized into two major directions. The first is training; creativity can be improved by developing metacognitive skills by imagery training to generate new ideas and cultivate divergent thinking (May et al., 2020). The innovative capabilities of college students are not inborn and unchangeable but can be improved by training and practices that integrate active participation and clear guidance for individuals and teams (Tran, Kudrowitz, & Koutstaal, 2020). The second direction is entrepreneurship education and entrepreneurial intention. Developing students' creativity in higher education institutions is a vital outcome of entrepreneurial education in terms of stimulating college students' innovativeness (Shi, Yuan, Bell, & Wang, 2020). Increasing self-perceived creativity in college courses can raise students' entrepreneurial intentions by intensifying entrepreneurial self-efficacy (Laguía et al., 2019).

Figure 7. Weighted time-zone map of the research keywords from 2011 to 2021.

5. RESEARCH IMPLICATIONS

Today's world has entered the era of a knowledge economy that is dominated by modern high-tech industries. As a widely recognized indicator that measures the sustainability and vitality of a country's or region's economy, innovativeness has become the most important factor and decisive force of economic growth and social progress in this era. The advent of the knowledge economy not only poses challenges to the innovativeness of college students in modern society, but also breeds potential opportunities for cultivating their innovative abilities. One of the core tasks of higher learning institutions is to train high-quality talents with innovative consciousness, thinking and abilities because college is a critical period for developing such capacities. However, with increasingly fierce markets and social competition, college students will be confronted with more pressure to find jobs after graduation. As a result, college students should be able to transform knowledge into wealth, as knowledge is the most prominent factor in wealth growth in a knowledge economy society. Through the reform of higher education, research from academic communities, efforts by governments, and participation by business communities, the innovativeness of college students will be continuously improved to realize the sustainable development of the corresponding individuals and humanity.

6. CONCLUSIONS

Based on the visual and bibliometric review of the literature obtained from the Web of Science Core Collection from 2011 to 2021, the results show that the innovativeness of college students is still a hot area of research, and the number of papers published in academic journals is increasing each year. The top four most cited articles in this research field with more than 175 citations in the Web of Science database mainly explore innovativeness from giftedness, Instagram, Facebook, and active learning. Regarding the academic journals that focus on this specific research area, the *International Journal of Engineering Education* and the *Creativity Research Journal* are the most influential publishers with more than 40 publications in the past decade, while the most co-cited journals are the *Creativity Research Journal*, the *Journal of Personality and Social Psychology*, and the *Journal of Creative Behavior*. The leading authors in this field can be clustered into three major collaborative networks with specific research interests within each group. In terms of the productive countries or territories, it is noticeable that the number of articles contributed by the USA is three times the number of publications by the country in second place and eight times that of the country in third place. At the same time, all the top ten most prolific institutions are from the USA, and the contributing universities can be grouped into four major clusters based on their cooperation.

The co-occurrence analysis of keywords reveals five major research hotspots: (1) creativity in educational innovation; (2) innovation in design education and engineering education; (3) entrepreneurship in higher education; (4) creativity from divergent thinking, personality, and motivation; and (5) the curriculum for first-year and second-year undergraduates. The emerging research trends are shown as training, entrepreneurship education, and entrepreneurial intention.

The results provide valuable information for the status quo of the research on the innovativeness of college graduates and identify hot research themes, potential topics, and research trends. Since college students are the backbone of a country's future, the key driver of economic prosperity and the problem solver for the issues concerning sustainable development, such as changing climate, social inequalities, and the contradiction between the security of food, the productivity of energy, and the protection of environment (Harvey & Pilgrim, 2011), the cultivation of their innovative capabilities will remain high on the agenda for governments, higher education institutions, and students themselves in this increasingly competitive world. The findings of this paper can be used in decision making for government officials, educational reform for colleges and universities, and the research priorities for researchers.

Funding: This research is supported by the Ph.D. Research Start-up Fund of Panzhihua University (Grant number: 035200187).
Competing Interests: The authors declare that they have no competing interests.
Authors' Contributions: Both authors contributed equally to the conception and design of the study.

REFERENCES

Ahamad, N. R., & Ariffin, M. (2018). Assessment of knowledge, attitude and practice towards sustainable consumption among university students in Selangor, Malaysia. *Sustainable Production and Consumption*, *16*, 88-98. https://doi.org/10.1016/j.spc.2018.06.006

Alden, E. (2017). ConfChem Conference on Select 2016 BCCE presentations: Changing roles for changing times—social media and the evolution of the supplemental instructor. *Journal of Chemical Education*, *94*(12), 2007-2009. https://doi.org/10.1021/acs.jchemed.6b01012

Amabile, T. M. (1982). Social psychology of creativity: A consensual assessment technique. *Journal of Personality and Social Psychology*, *43*(5), 997-1013. https://doi.org/10.1037/0022-3514.43.5.997

An, D., Song, Y., & Carr, M. (2016). A comparison of two models of creativity: Divergent thinking and creative expert performance. *Personality and Individual Differences*, *90*, 78-84. https://doi.org/10.1016/j.paid.2015.10.040

Andrews, T. M., Leonard, M. J., Colgrove, C. A., & Kalinowski, S. T. (2011). Active learning not associated with student learning in a random sample of college biology courses. *CBE—Life Sciences Education*, *10*(4), 394-405.

Arteaga Sánchez, R., Cortijo, V., & Javed, U. (2014). Students' perceptions of Facebook for academic purposes. *Computers & Education*, *70*, 138-149. https://doi.org/10.1016/j.compedu.2013.08.012

Astebro, T., Bazzazian, N., & Braguinsky, S. (2012). Startups by recent university graduates and their faculty: Implications for university entrepreneurship policy. *Research Policy*, *41*(4), 663-677. https://doi.org/10.1016/j.respol.2012.01.004

Banyard, V. L., & Moynihan, M. M. (2011). Variation in bystander behavior related to sexual and intimate partner violence prevention: Correlates in a sample of college students. *Psychology of Violence*, *1*(4), 287-301. https://doi.org/10.1037/a0023544

Barrett, J. D., Peterson, D. R., Hester, K. S., Robledo, I. C., Day, E. A., Hougen, D. P., & Mumford, M. D. (2013). Thinking about applications: Effects on mental models and creative problem-solving. *Creativity Research Journal*, *25*(2), 199–212. https://doi.org/10.1080/10400419.2013.783758

Birkle, C., Pendlebury, D. A., Schnell, J., & Adams, J. (2020). Web of Science as a data source for research on scientific and scholarly activity. *Quantitative Science Studies*, *1*(1), 363-376.

Blewitt, J., & Senior, C. (2010). Higher education for a sustainable world. *Education & Training (London)*, *52*(6/7), 477-488.

Borgen, K. B., Ropp, T. D., & Weldon, W. T. (2021). Assessment of augmented reality technology's impact on speed of learning and task performance in aeronautical engineering technology education. *The International Journal of Aerospace Psychology*, *31*(3), 219-229. https://doi.org/10.1080/24721840.2021.1881403

Braßler, M., & Schultze, M. (2021). Students' innovation in education for sustainable development—a longitudinal study on interdisciplinary vs. monodisciplinary learning. *Sustainability*, *13*(3), 1-17.

Brito, J. C., Durant, S. M., Pettorelli, N., Newby, J., Canney, S., Algadafi, W., . . . Wacher, T. (2018). Armed conflicts and wildlife decline: Challenges and recommendations for effective conservation policy in the Sahara-Sahel. *Conservation Letters*, *11*(5), e12446. https://doi.org/10.1111/conl.12446

Cantú-Ortiz, F. J., Galeano Sánchez, N., Garrido, L., Terashima-Marin, H., & Brena, R. F. (2020). An artificial intelligence educational strategy for the digital transformation. *International Journal on Interactive Design and Manufacturing*, *14*(4), 1195-1209.

Carson, S. H., Peterson, J. B., & Higgins, D. M. (2005). Reliability, validity, and factor structure of the creative achievement questionnaire. *Creativity Research Journal*, *17*(1), 37-50. https://doi.org/10.1207/s15326934crj1701_4

Carter, C., Hass, R. W., Charfadi, M., & Dinzeo, T. J. (2019). Probing linear and nonlinear relations among schizotypy, hypomania, cognitive inhibition, and creativity. *Creativity Research Journal*, *31*(1), 83-92. https://doi.org/10.1080/10400419.2019.1580091

Chang, S.-H., Shu, Y., Wang, C.-L., Chen, M.-Y., & Ho, W.-S. (2020). Cyber-entrepreneurship as an innovative orientation: Does positive thinking moderate the relationship between cyber-entrepreneurial self-efficacy and cyber-entrepreneurial intentions in Non-IT students? *Computers in Human Behavior*, *107*, 105975. https://doi.org/10.1016/j.chb.2019.03.039

Chen, C., Dubin, R., & Kim, M. C. (2014). Orphan drugs and rare diseases: A scientometric review (2000–2014). *Expert Opinion on Orphan Drugs*, *2*(7), 709-724. https://doi.org/10.1517/21678707.2014.920251

Chen, X., & Liu, Y. (2020). Visualization analysis of high-speed railway research based on CiteSpace. *Transport Policy*, *85*, 1-17. https://doi.org/10.1016/j.tranpol.2019.10.004

Dai, F., Wei, K., Chen, Y., & Ju, M. (2019). Construction of an index system for qualitative evaluation of undergraduate nursing students innovative ability: A Delphi study. *Journal of Clinical Nursing*, *28*(23-24), 4379-4388. https://doi.org/10.1111/jocn.15020

Day, T. (2012). Undergraduate teaching and learning in physical geography. *Progress in Physical Geography*, *36*(3), 305–332. https://doi.org/10.1177/0309133312442521

Frey, R. F., Fink, A., Cahill, M. J., McDaniel, M. A., & Solomon, E. D. (2018). Peer-led team learning in general chemistry I: Interactions with identity, academic preparation, and a course-based intervention. *Journal of Chemical Education*, *95*(12), 2103-2113. https://doi.org/10.1021/acs.jchemed.8b00375

Genco, N., Hölttä-Otto, K., & Seepersad, C. C. (2012). An experimental investigation of the innovation capabilities of undergraduate engineering students. *Journal of Engineering Education*, *101*(1), 60-81. https://doi.org/10.1002/j.2168-9830.2012.tb00041.x

Gibson, C., & Mumford, M. D. (2013). Evaluation, criticism, and creativity: Criticism content and effects on creative problem solving. *Psychology of Aesthetics, Creativity, and the Arts*, *7*(4), 314. https://doi.org/10.1037/a0032616

Gugerty, P., & Teeven, B. (2015). Leadership and creativity are important for undergraduate students: Our journey. *Journal of Leadership Studies*, *9*(3), 90-91. https://doi.org/10.1002/jls.21419

Guilford, J. P. (1956). The structure of intellect. *Psychological Bulletin Journal*, *53*(4), 267-293.

Gulati, R. R., Reid, H., & Gill, M. (2020). Instagram for peer teaching: Opportunity and challenge. *Education for Primary Care*, *31*(6), 382-384. https://doi.org/10.1080/14739879.2020.1811163

Guo, J., Zhang, J., & Pang, W. (2021). Parental warmth, rejection, and creativity: The mediating roles of openness and dark personality traits. *Personality and Individual Differences*, *168*, 110369. https://doi.org/10.1016/j.paid.2020.110369

Hao, C. (2021). An exploratory research on constructing a model of innovation and entrepreneurship education for college students based on fuzzy neural network algorithm. *Security and Communication Networks*, 1-8. https://doi.org/10.1155/2021/5533376

Harvey, M., & Pilgrim, S. (2011). The new competition for land: Food, energy, and climate change. *Food Policy*, *36*, S40-S51. https://doi.org/10.1016/j.foodpol.2010.11.009

Hester, K. S., Robledo, I. C., Barrett, J. D., Peterson, D. R., Hougen, D. P., Day, E. A., & Mumford, M. D. (2012). Causal analysis to enhance creative problem-solving: Performance and effects on mental models. *Creativity Research Journal*, *24*(2-3), 115–133. https://doi.org/10.1080/10400419.2012.677249

Holden, W. N. (2019). Endogenous exacerbation of an exogenous problem: Climate change, environmental degradation, and unsustainable development practices in the Philippines. *Asian Geographer*, *36*(1), 1-27. https://doi.org/10.1080/10225706.2018.1483831

Hou, Y. R. (2019). *Research on cultivation of innovative and entrepreneurial ability of college students in big data environment*. Paper presented at the In: 2019 4th International Conference on Education & Education Research. Zheng Z. (ed). 2019 4th International Conference on Education & Education Research. FRANCIS ACAD PRESS. Wuhan.

Hu, S., Ding, Z., & Ni, Q. (2016). Beamforming optimisation in energy harvesting cooperative full-duplex networks with self-energy recycling protocol. *IET Communications*, *10*(7), 848-853. https://doi.org/10.1049/iet-com.2015.0476

Jamieson, M. V., & Shaw, J. M. (2019). Teaching engineering for a changing landscape. *The Canadian Journal of Chemical Engineering*, *97*(11), 2870-2875. https://doi.org/10.1002/cjce.23626

Jung, K., Lee, S.-H., & Workman, J. E. (2018). Exploring a relationship between creativity and public service motivation. *Knowledge Management Research & Practice*, *16*(3), 292-304. https://doi.org/10.1080/14778238.2018.1471327

Kaufman, J. C. (2012). Counting the muses: Development of the Kaufman Domains of creativity scale (K-DOCS). *Psychology of Aesthetics, Creativity, and the Arts*, *6*(4), 298-308. https://doi.org/10.1037/a0029751

Kim, K. (2017). The torrance tests of creative thinking - figural or verbal: Which one should we use? *Creativity Theories – Research - Applications*, *4*(2), 302-321. https://doi.org/10.1515/ctra-2017-0015

Kumar, N., Pandey, S., & Rahman, E. (2021). A novel three-dimensional interactive virtual face to facilitate facial anatomy teaching using Microsoft HoloLens. *Aesthetic Plastic Surgery*, *45*(3), 1005-1011.

Kupers, E., Lehmann-Wermser, A., McPherson, G., & Van Geert, P. (2019). Children's creativity: A theoretical framework and systematic review. *Review of Educational Research*, *89*(1), 93-124. https://doi.org/10.3102/0034654318815707

Laguía, A., Moriano, J. A., & Gorgievski, M. J. (2019). A psychosocial study of self-perceived creativity and entrepreneurial intentions in a sample of university students. *Thinking Skills and Creativity*, *31*, 44-57. https://doi.org/10.1016/j.tsc.2018.11.004

Lee, J. W., Daly, S. R., Huang-Saad, A., Rodriguez, G., DeVries, Q., & Seifert, C. M. (2021). A solution in search of problems: A cognitive tool for solution mapping to promote divergent thinking. *Journal of Engineering Design*, *32*(6), 300-321. https://doi.org/10.1080/09544828.2021.1887462

Li, G. (2017). Role of innovation and entrepreneurship education in improving employability of Medical University students. *EURASIA Journal of Mathematics, Science and Technology Education*, *13*(12), 8149-8154. https://doi.org/10.12973/ejmste/80779

Linsey, J. S., Clauss, E. F., Kurtoglu, T., Murphy, J. T., Wood, K. L., & Markman, A. B. (2011). An experimental study of group idea generation techniques understanding the roles of idea representation and viewing methods. *Journal of Mechanical Design*, *133*(3), 031008. https://doi.org/10.1115/1.4003498

Markowitz, E. M., Goldberg, L. R., Ashton, M. C., & Lee, K. (2012). Profiling the "pro-environmental individual": A personality perspective. *Journal of Personality*, *80*(1), 81-111. https://doi.org/10.1111/j.1467-6494.2011.00721.x

May, J., Redding, E., Whatley, S., Łucznik, K., Clements, L., Weber, R., . . . Reed, S. (2020). Enhancing creativity by training metacognitive skills in mental imagery. *Thinking Skills and Creativity*, *38*, 100739. https://doi.org/10.1016/j.tsc.2020.100739

McIntosh, T., Mulhearn, T. J., & Mumford, M. D. (2021). Taking the good with the bad: The impact of forecasting timing and valence on idea evaluation and creativity. *Psychology of Aesthetics, Creativity, and the Arts*, *15*(1), 111–124. https://doi.org/10.1037/aca0000237

McWilliam, E. (2009). Teaching for creativity: From sage to guide to meddler. *Asia Pacific Journal of Education*, *29*(3), 281-293. https://doi.org/10.1080/02188790903092787

Medeiros, K. E., Steele, L. M., Watts, L. L., & Mumford, M. D. (2018). Timing is everything: Examining the role of constraints throughout the creative process. *Psychology of Aesthetics, Creativity, and the Arts*, *12*(4), 471–488. https://doi.org/10.1037/aca0000148

Mizrachi, D., & Bates, M. J. (2013). Undergraduates' personal academic information management and the consideration of time and task-urgency. *Journal of the American Society for Information Science and Technology*, *64*(8), 1590-1607. https://doi.org/10.1002/asi.22849

Obeid, S., & Demirkan, H. (2020). The influence of virtual reality on design process creativity in basic design studios. *Interactive Learning Environments*, 1-19. https://doi.org/10.1080/10494820.2020.1858116

Partlow, P. J., Medeiros, K. E., & Mumford, M. D. (2015). Leader cognition in vision formation: Simplicity and negativity. *The Leadership Quarterly*, *26*(3), 448–469. https://doi.org/10.1016/j.leaqua.2015.02.009

Peterson, D. R., Barrett, J. D., Hester, K. S., Robledo, I. C., Hougen, D. F., Day, E. A., & Mumford, M. D. (2013). Teaching people to manage constraints: Effects on creative problem-solving. *Creativity Research Journal*, *25*(3), 335–347. https://doi.org/10.1080/10400419.2013.813809

Peterson, K., Sharps, P., Banyard, V., Powers, R. A., Kaukinen, C., Gross, D., & Campbell, J. (2018). An evaluation of two dating violence prevention programs on a college campus. *Journal of Interpersonal Violence*, *33*(23), 3630-3655. https://doi.org/10.1177/0886260516636069

Phelps, E. (2014). Mass flourishing. How grassroots innovation created jobs, challenge, and change. *Business Economics*, *49*(3), 203-205.

Plucker, J. A., Beghetto, R. A., & Dow, G. T. (2004). Why isn't creativity more important to educational psychologists? Potentials, pitfalls, and future directions in creativity research. *Educational Psychologist*, *39*(2), 83-96. https://doi.org/10.1207/s15326985ep3902_1

Pravder, H. D., Langdon-Embry, L., Hernandez, R. J., Berbari, N., Shelov, S. P., & Kinzler, W. L. (2021). Experiences of early graduate medical students working in New York hospitals during the COVID-19 pandemic: A mixed methods study. *BMC Medical Education*, *21*(1), 1-11. https://doi.org/10.1186/s12909-021-02543-9

Qu, Z., Huang, W., & Zhou, Z. (2020). Applying sustainability into engineering curriculum under the background of "new engineering education" (NEE). *International Journal of Sustainability in Higher Education*, *21*(6), 1169-1187.

Richardson, C., & Mishra, P. (2018). Learning environments that support student creativity: Developing the SCALE. *Thinking Skills and Creativity*, *27*, 45-54. https://doi.org/10.1016/j.tsc.2017.11.004

Runco, M. A., Plucker, J. A., & Lim, W. (2001). Development and psychometric integrity of a measure of ideational behavior. *Creativity Research Journal*, *13*(3-4), 393-400. https://doi.org/10.1207/s15326934crj1334_16

Sandri, O. J. (2013). Exploring the role and value of creativity in education for sustainability. *Environmental Education Research*, *19*(6), 765-778. https://doi.org/10.1080/13504622.2012.749978

Selznick, B. S., & Mayhew, M. J. (2018). Measuring undergraduates' innovation capacities. *Research in Higher Education*, *59*(6), 744-764. https://doi.org/10.1007/s11162-017-9486-7

Sheldon, P., & Bryant, K. (2016). Instagram: Motives for its use and relationship to narcissism and contextual age. *Computers in Human Behavior*, *58*, 89-97. https://doi.org/10.1016/j.chb.2015.12.059

Shi, Y., Yuan, T., Bell, R., & Wang, J. (2020). Investigating the relationship between creativity and entrepreneurial intention: The moderating role of creativity in the theory of planned behavior. *Frontiers in Psychology*, *11*, 1209. https://doi.org/10.3389/fpsyg.2020.01209

Shiau, W.-L., & Chau, P. Y. (2016). Understanding behavioral intention to use a cloud computing classroom: A multiple model comparison approach. *Information & Management*, *53*(3), 355-365. https://doi.org/10.1016/j.im.2015.10.004

Shoop, B. L., & Ressler, E. K. (2011). Developing the critical thinking, creativity and innovation of undergraduate engineering students. *International Journal of Engineering Education*, *27*(5), 1072-1080. https://doi.org/10.1117/12.2068495

Southworth, E., & Gleason, S. H. (2021). COVID 19: A cause for pause in undergraduate medical education and catalyst for innovation. *HEC Forum*, *33*(1-2), 125-142.

Steele, L. M., Hardy, J. H. I., Day, E. A., Watts, L. L., & Mumford, M. D. (2021). Navigating creative paradoxes: Exploration and exploitation effort drive novelty and usefulness. *Psychology of Aesthetics, Creativity, and the Arts*, *15*(1), 149–164. https://doi.org/10.1037/aca0000236

Subotnik, R. F., Olszewski-Kubilius, P., & Worrell, F. C. (2011). Rethinking giftedness and gifted education: A proposed direction forward based on psychological science. *Psychological Science in the Public Interest*, *12*(1), 3-54. https://doi.org/10.1177/1529100611418056

Taylor, C. L., Esmaili Zaghi, A., Kaufman, J. C., Reis, S. M., & Renzulli, J. S. (2020). Divergent thinking and academic performance of students with attention deficit hyperactivity disorder characteristics in engineering. *Journal of Engineering Education*, *109*(2), 213-229.

Tekmen-Araci, Y., & Mann, L. (2019). Instructor approaches to creativity in engineering design education. *Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science*, *233*(2), 395-402. https://doi.org/10.1177/0954406218758795

Touahmia, M., Ait-Messaoudene, N., Aichouni, M., Al-Ghamdi, A., Elbadawi, I., Al-Hamali, R., & Al-Ghonamy, A. (2017). Assessment of creativity and innovation at a Saudi University. *International Journal of Advanced and Applied Sciences*, *4*(5), 48-55.

Tran, K. N., Kudrowitz, B., & Koutstaal, W. (2020). Fostering creative minds: What predicts and boosts design competence in the classroom? *International Journal of Technology and Design Education*, 1-32.

Urban, S. (2017). Pen-enabled, real-time student engagement for teaching in STEM subjects. *Journal of Chemical Education*, *94*(8), 1051-1059. https://doi.org/10.1021/acs.jchemed.7b00127

Valentine, A., Belski, I., Hamilton, M., & Adams, S. (2019). Creativity in electrical engineering degree programs: Where is the content? *IEEE Transactions on Education*, *62*(4), 288-296. https://doi.org/10.1109/te.2019.2912834

Van Eck, N., & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics*, *84*(2), 523-538. https://doi.org/10.1007/s11192-009-0146-3

Vessey, W. B., Barrett, J., & Mumford, M. D. (2011). Leader cognition under threat: "Just the Facts.". *The Leadership Quarterly*, *22*(4), 710–728. https://doi.org/10.1016/j.leaqua.2011.05.011

Wang, H., Ren, A., Wang, H., & Yu, D. (2018). *Research on the cultivation method of mechanical innovation ability for college students in new Era*. Paper presented at the In 2018 2nd International Conference on Education, Economics and Management Research (ICEEMR 2018), Atlantis Press.

Watts, L. L., McIntosh, T. J., Gibson, C., Mulhearn, T. J., Medeiros, K. E., Mecca, J. T., & Cohen-Charash, Y. (2020). Mild affective shifts and creativity: Effects on idea generation, evaluation, and implementation planning. *The Journal of Creative Behavior*, *54*(4), 985-1001. https://doi.org/10.1002/jocb.427

Wen, Z., Liu, X., Beaulieu, N. C., Wang, R., & Wang, S. (2016). Joint source and relay beamforming design for full-duplex MIMO AF relay SWIPT systems. *IEEE Communications Letters*, *20*(2), 320-323.

Williams, B. (2020). Dimensions & VOSViewer bibliometrics in the reference interview. *Code4Lib Journal*, *47*.

Wu, D., Shen, H., & Lv, Z. (2021). An artificial intelligence and multimedia teaching platform based integration path of IPE and IEE in colleges and universities. *Journal of Intelligent & Fuzzy Systems*, *40*(2), 3767-3776. https://doi.org/10.3233/jifs-189410

Xue, Y., Bradley, J., & Liang, H. (2011). Team climate, empowering leadership, and knowledge sharing. *Journal of Knowledge Management*, *15*(2), 299-312.

Xueshudiandi. (2020). COOC: A new software for bibliometrics and knowledge mapping. Retrieved from: https://mp.weixin.qq.com/s/Igng9UyO9rTAHd0B4lD_4g. [Accessed Jan-06 2021].

Zhang, Q., Liu, C., Wang, Z., & Yang, Z. (2020). The college students' sense of responsibility for innovation and entrepreneurship. *Frontiers in Psychology*, *11*, 1-13. https://doi.org/10.3389/fpsyg.2020.02049